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Continuous Records of DO Contents by Cruising in the Coastal Culture Farms - II[*1]

Diffusion of Suspended Particles by Feeding

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Abstract

The observations were made to find out the mechanism of suspended particles diffusion in waters around the fish floating cages after feeding.

Water samples were taken around the culture farms by using polyethylene bottles near the Fishery Research Laboratory, Faculty of Fisheries, Kagoshima University. Suspended particles were determined immediately after sampling on board a 5-tonne vessel Azuma by using a Coulter Counter model ZB. Bacterial population densities were determined using a modified ZoBell's medium.

Average weight of the bio-deposits was 37.2 dry-g/m^2/day. The maximum amount, 91.0 dry-g/m^2/day, was observed in the end of October when the fish were fed the maximum foods, 3375 kg/day. The amounts of bio-deposits were closely related to the amounts of foods supplied in fish cages.

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Foreword

Coastal waters are indispensable fishing grounds for fisheries using boats and for shallow water fish farming. The tendency is increasing to reevaluate the coastal waters now that the recent 200-nautical-mile sea law is coming into effect. Yet, acting against this trend, the degree of environmental pollution in coastal waters keeps rising every year, working thus apparently in an opposite direction (Murakami, 1976). At the present time, it is an extremely important task to study the environment and physiology of the aquatic species in the coastal fishing grounds in order to rationalize the use of fishing grounds for boats and to preserve the environment of the shallow fish farming grounds.

So, with the purpose of understanding the environmental physiological mechanism of shallow fish farming stations, we reported previously (Kadowaki et al, 1978) on the correlation between the occurrence of dropping oxygen levels around fish cages and the fish-holding density, using the continuous DO recording method by cruising (Hirata et al 1978 a). Yet as the suspended matters produced through feeding are thought to be one of the causes inducing decreases in oxygen, we decided in the present study to examine the correlation between the dispersion of these suspended matters on the one hand and DO on the other. p. 282

The physical behavior of the self-pollution substances produced through fish-feeding has already been outlined by Hagino (1977) and Tanaka (1977) but there remain some questions such as the mixing and dispersion of floating and suspended matters immediately following feeding (Hagino 1977). In the present study we used a Coulter counter

to examine the behavior of these matters immediately after feeding, and discovered that these same matters contribute to the drop in DO and to the increasein bacterial numbers. Our results are as follows.

Before starting, however, I wish to thank Yaoki YAMASHITA, president of the Yamashita Fisheries Co. who was very helpful in the course of the present study conducted around the fish cages. I am also grateful to Gunzo KAWAMURA of the Fisheries Department of the Kagoshima University, to Eiichi KOHIRADA, technician, to P. Gabasa, Masatoshi KODAMA, Koji MAE, Masahiko MAEDA, Masanori TSURUMARU, graduate students of the breeding physiology section of the same Fisheries Department and to Muneyuki MATSUDA, research student for all the help received. Part of this study was financed by the Mitsuwa Kasei Co. I thank all those who helped in obtaining this grant.

Method

This survey was conducted from October 1977 to July 1978. That is, during the period from October to December when maximum feeding is carried out, we examined the correlation between the amounts of feed and of suspended matters. Later, in order to analyze the behavior of the floating and suspended matters, we examined the amounts of suspended matters and the degree of transparency (1978, January), the variations in DO during feeding (February of the same year), the distribution of bacteria (July, same year) and the like.

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To collect bottom sediments, we cut out the bottoms of 5 L polyethylene bottles, lowered them at sites removed about 60-80 cm from the sea floor and gathered them every 4-5 days. The weights were measured after drying with a dryer.

Regarding the DO variations during feeding, we proceeded practically as explained in the former report (Kadowaki et al 1978). However, when measuring, we moved at a distance of 5-7 m away from the fish cages as we had to travel by while avoiding the feed boats.

To measure the floating and suspended matters we followed the method of Hirata et al (1978 b), using a ZB type Coulter counter. To adjust the counter, we set the aperture tube at 280 μ, chose 10 K matching, 6 gain trim, 1 amplification and a 0.177 aperture current. The size composition of the floating and suspended matters was measured with a microscope.

For the bacterial count, we used a ZoBell modified culture (HIDAKA and KAKIMOTO, 1968) and examined by the Most Probable Number (MPN) method.

To collect water for the Coulter counter and for the MPN method we dived, holding by hand vinyl chloride pipes with a 3 cm diameter and of a 27 cm length, and returned them to the boat after putting gum bung at both ends in determined places right under or around the fish cages. The survey boat was the Azuma (5 tonnes) of this Fisheries laboratory. The Coulter counter-based counts were performed aboard rapidly after collecting the water.

As in the previous study, the site of the survey was the Usui fish farming area of Azuma, Izumi Township, Kagoshima Prefecture.

Results p. 283

Fig. 2 shows the results regarding the volumes of feed provided and of the accumulated suspensions. When the survey was started on October 20 the volume of daily feed was relatively low at 1.4 tonnes/day. In November it was about 2 tonnes. Later the volume was gradually increased. From late November to early December the amount decreased again down to 0.8 tonnes/day.

Meanwhile, the dry weight of the sediments during this period was first 35.5 g/m^2/day. At the high time of November it rose to 45 g/m^2/day. Later, as the feeding volume decreased, the sediments decreased accordingly. At the end, in mid-December, the amount of sediments was calculated to be 20 g/m^2/day.

The results indicate that when the amount of feed increased by 1.4, the amount of sediments increased by 1.3. Conversely when the amount p. 284 of feed decreased by 1/2.5, the amount of sediment decreased by 1/2.3. Consequently we were able to find a strong correlation between the amounts of feed provided and that of the sediments.

We examined thereafter the floating and suspended matters. At first, the size was 10-80 μ. At the peak it was about 30 μ as shown in Fig. 3. Such floating and suspended matters increase 2-3 times during feeding. Moreover, at that time DO showed a decrease of the 0.2-0.6 ppm order (Fig. 4).

Fig. 5 shows the time-course variations of the volume of floating and suspended matters on the one hand and of transparency on the other accompanying feeding in the 0-4 m layer. The Fig. shows clearly that

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the volume of floating and suspended matters increases almost twofold at feeding time and that the concomitant transparency dropped to 9 m from 11 m. So, a clear reverse correlation is noted between the volume of suspended matters and transparency. However, about 1 h later, normal conditions were restored. Table 1 shows the vertical distribution of the floating and suspended matters. In the 0 layer, the feeding effect increased almost twofold and showed to be greatest. In the 4-6 m layer there was no difference between before and after feeding.

We examined the variations in the dispersion of the floating and suspended matters around and right under the fish cages. The results are shown in Fig. 6. Right under the fish cages, the volume of suspended matters was twice the volume around the cages. When we examined the bacteria concentration, almost the same tendency was discovered. This is shown in Table 2.

The bacterial density right under the fish cages exceeded 8.04 log N/mL and the concentration around the cages was 5.36 log N/mL. Meanwhile, the bacterial concentration in the offshore waters about 1 km away was less than 4.00 log N/mL. p. 286

For the floating and suspended matters, we found the 442 N/mL relative value right under the cages. Around the cages, the average relative value was 272 N/mL. So, we discovered a positive correlation between the bacterial density on the one hand and the increase-decrease of floating and suspended matters on the other. p. 287

Discussion

We examined the scattering of the floating and suspended matters accompanying the feeding of cultured yellowtail, and saw that the amount increases twofold right after feeding. This tendency was particularly strong under the cages. As Hagino (1977) indicated, the amount of floating and suspended matters right after feeding or right under the cages was not known in the surveys. One of the reasons was apparently problems of methods. It is easy to collect water under the cages by diving. Yet even when diving before and after feeding, sometimes the yellowtail do not take the feed so that it is extremely difficult to collect water at a determined time in a determined place. This was our first problem.

Next, we must remember that the swimming of yellowtail produces counter-currents in the current around the fish cages (Minamizawa, 1976). The direction and speed of the current is particularly complex at feeding time. It is consequently difficult to make a microanalysis of the dispersion of the floating and suspended matters. As Table 1 obtained through the present survey indicates, the amount of floating and suspended matters in the 4-6 m layer showed no variation before and after feeding. We think that it is because of the counter-currents.

Inoue (1971) examined the oxygen consumption, based on the botton mud rising to the surface. Nakamura and Hagino (1973) discussed the method of estimating the dispersion of dissolved suspensions. At the time, DO was given as one index. In the former report, we calculated the oxygen consumption volume for all cages based on DO continuous recording by cruising (Kadowaki et al, 1978). As in this report we consider also the oxygen consumption based on floating and suspended

matters, we must perform indoor tests in order to find the correlation between floating-suspended matters and DO.

We found a high correlation between the calculated numerical values based on the Coulter counter and the bacterial count based on the MPM method. On this point we wish to add an examination using the reports made by Ichikawa and Nishizawa (1975), Ishida et al (1978).

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* Translator note: Probable reading only; not quite certain.

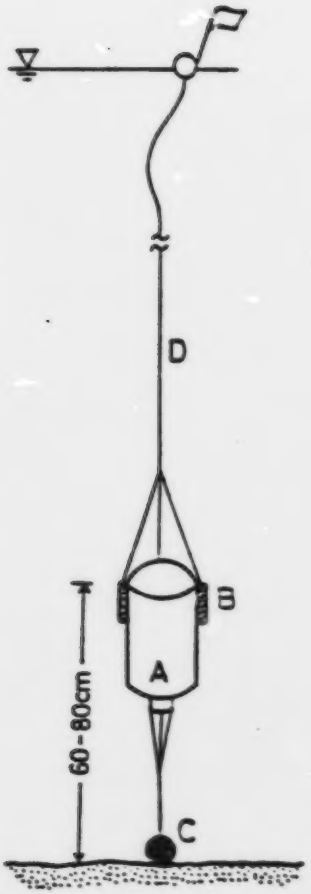

Fig. 1. Schematic view of collector.

A: polyethylene bottle (5 liters), B: float, C: weight, D: Cremona rope in 8mm diameter.

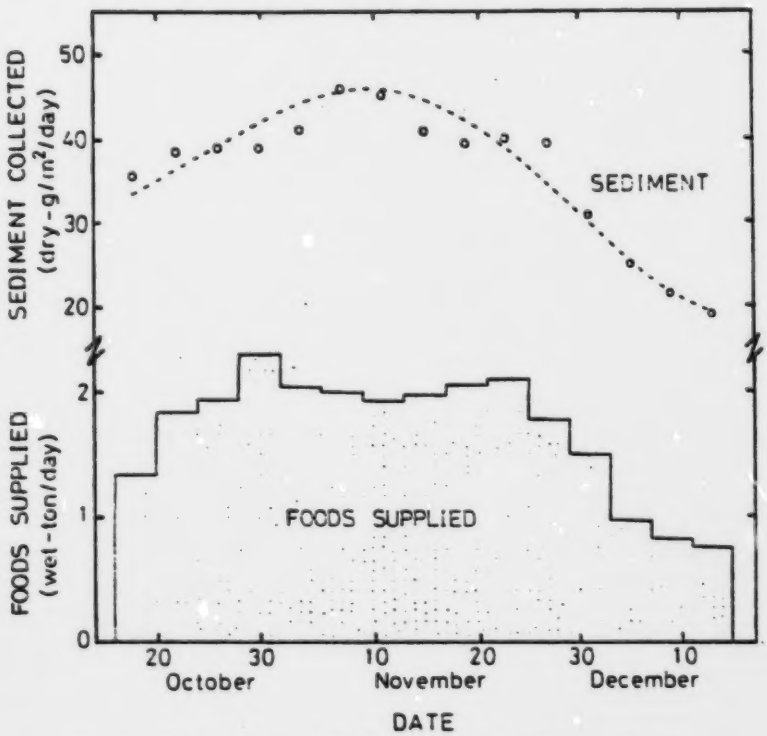

Fig. 2. Relation between food supplied and sediment collected.

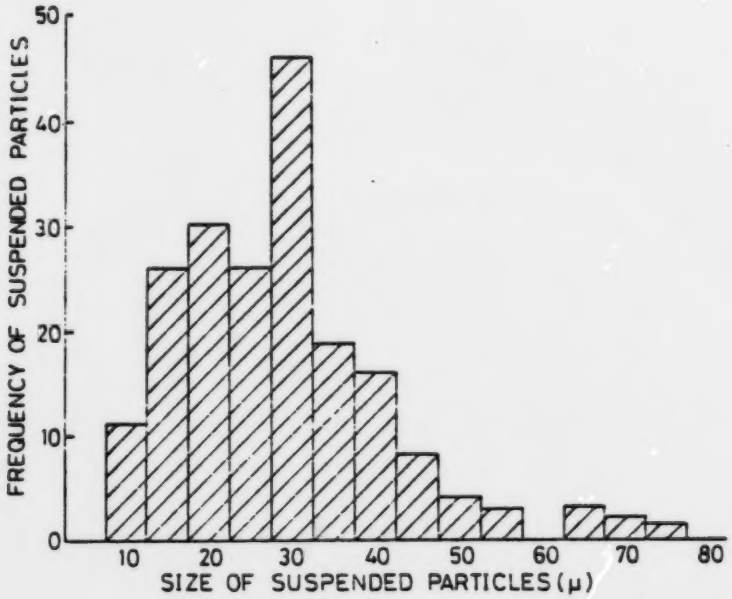

Fig. 3. Size distribution of suspended particles measured by microscope.

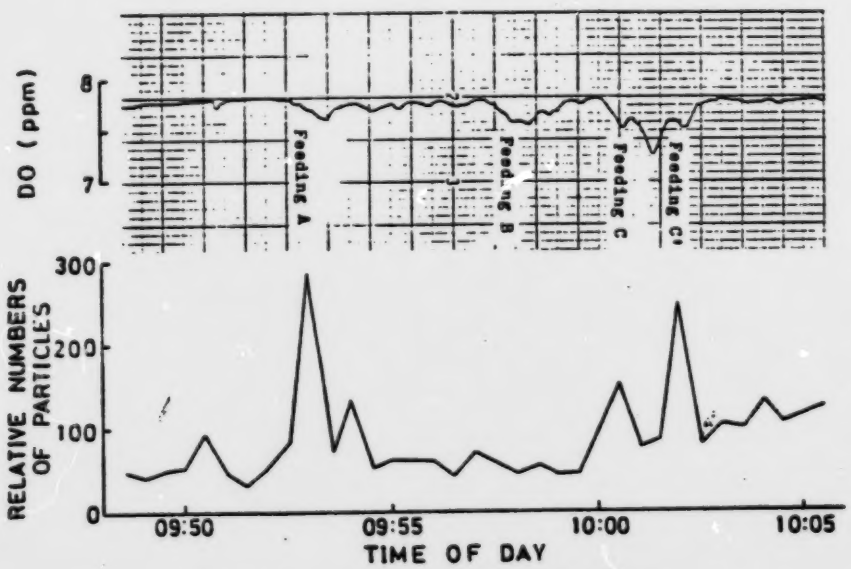

Fig. 4. Variations of DO content and number of particles during feeding.

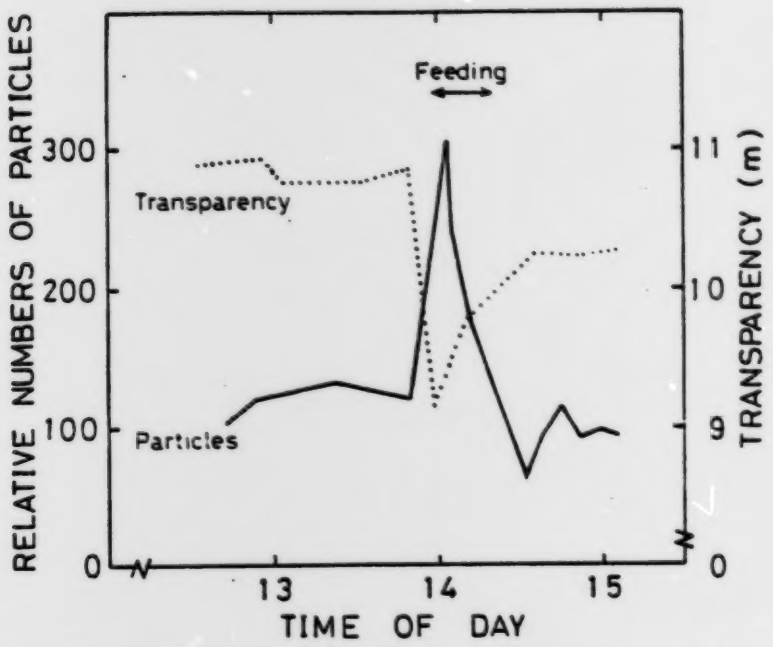

Fig. 5. Relation between density of particles and transparency in feeding.

Table 1. Vertical distribution of suspended particles. (number per ml).

Depth (m)	Pre-Feeding	Feeding	Post-Feeding	mean
0	126	223	102	129
2	113	157	88	109
4	106	100	96	101
6	132	138	92	116
8	118	159	90	112
mean	118	155	93	

Table 2. Correlation between density of particles and number of bacteria (log N/ml) at each station.

Station	Relative number of particles	Number of bacteria (log N/ml)
Bottom	442.1	8.04
Side	272.4	5.36
Off shore	253.2	4.00

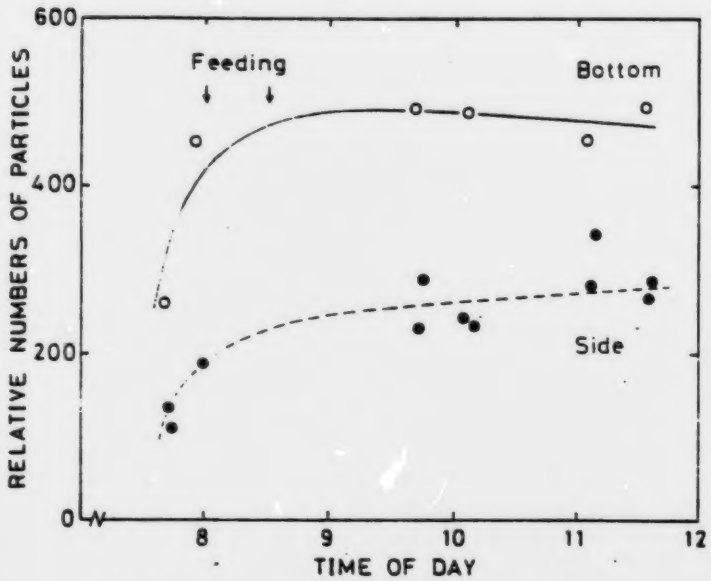

Fig. 3. Variation of particles around fish cages in feeding.